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The More Important Insects Injurious To The Sugar- Beet In Utah

I. M. HAWLEY



Fig. 2.— A sugar-beet
showing the effect of
feeding by the caterpillars
of the sugar-beet
webworm.

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THE MORE IMPORTANT INSECTS INJURIOUS TO THE SUGAR-BEET IN UTAH

By I. M. HAWLEY

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Introduction.—Insects destroy many sugar-beets in Utah. In some years the incomes of the farmers of the state are greatly reduced because of the ravages of these pests. This circular has been written in the hope that the more important information about the insect pests of this valuable crop may be more readily available to the beet growers of the state.

The insects treated in this paper are grouped under two main heads. In the first division are included those insects affecting the tops or foliage of the beet. In the second division are those insects that feed on the roots.

I. INSECTS THAT DESTROY TOPS OF SUGAR-BEETS

1.—SUGAR-BEET LEAFHOPPER

The sugar-beet leafhopper¹ is best known as the "white fly." It is the only insect that is able, by its feeding, to transmit the disease of sugar-beets known as curly-leaf. The causative factor that is carried from plant to plant by this leafhopper is still unknown, but the symptoms produced in a beet by the disease and the insect's part in the spread of the disease are better understood.

Curly-leaf does not appear every year in Utah beet fields, but it is often very destructive when it does occur. In some cases large fields have been plowed up early in the growing season and other crops planted. In other cases, beets that have

¹*Eutettix tenella* Baker

been left to complete their growth have not been worth harvesting. In 1905 the loss varied from 30 per cent in northern Utah to almost 100 per cent in the beet-growing counties farther south. In California, Idaho, and Oregon sugar factories have been abandoned or moved because of the curly-leaf disease. E. D. Ball, from whose work much of the data on this insect are taken, estimates that the total loss due to this insect from 1899 to 1916 was \$10,000,000 and that in 1905 alone the loss was \$500,000. It is estimated that the loss to the farmers in the Bear River Valley was \$1,500,000 in 1924.

Type of Injury.—The young tender leaves of a beet are the first attacked. The veins on the underside of these younger leaves become thickened or distorted, giving a rough and warty appearance to the foliage. These leaves curl up at the edges, thus exposing the roughened under-surface when the leaf is

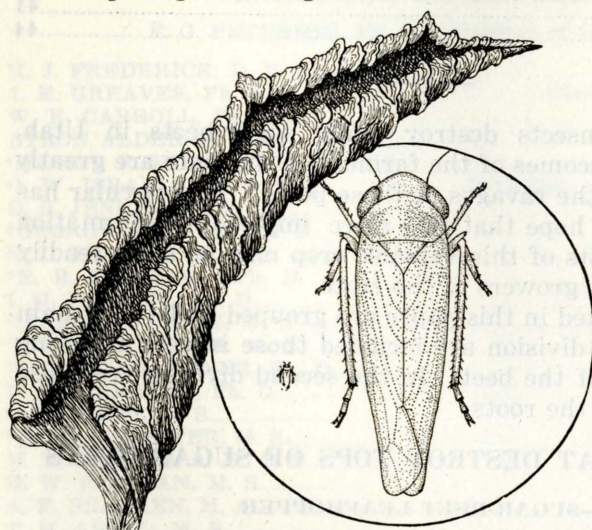


Fig. 1.—The sugar-beet leafhopper or white fly (*Eutettix tenella* Baker) and a leaf showing the symptoms of curly-leaf. (After Ball). Leafhopper enlarged 11 times.

viewed from above (Fig. 1). The petioles of affected plants are often shortened and the roots produce a mass of fine rootlets. If a diseased root is cut across, many dark rings are seen due to the discoloration of the water tubes. Plants attacked by curly-leaf when still small are usually killed outright; when plants have a good start before infection they may survive in a stunted condition, but the sugar content will be greatly reduced.

When the curly-leaf disease is in a plant, it affects all of the leaves that develop after the plant becomes infected. Experimental work has also shown that the older leaves of a beet often have the disease tho they may not show the external symptoms. If the first diseased leaves are removed and a new growth is produced, these also will be diseased. If beets that

have curly-leaf are held over for seed and are planted the second year, they will still show the symptoms of this disease. In recent experiments in California the disease has been carried by injecting some of the juice of a diseased beet into a healthy beet.

Hosts.—In addition to sugar-beets, table beets, and mangels, the sugar-beet leafhopper is known to breed on many closely related plants, especially saltbushes of the genus *Atriplex*. The more common of these plants found in Utah are known here as silver scale or saltbush², shadscale³, Australian saltbush or tumbling pigweed⁴. Other plants on which the insect lives and that occur in Utah are pigweed or lamb's quarters⁵, Russian thistle⁶, rough pigweed or red root⁷, tumble weed or prostrate redroot⁸, black nightshade⁹, orchard morning glory¹⁰, stork's bill or redstem filaree¹¹, and greasewood¹². Tho the leafhopper is found on greasewood, it is never present in large numbers, and Ball reports that this plant is probably not the original host plant as many believe.

Description.—The sugar-beet leafhopper passes thru three stages in its development: egg, nymph, and adult leafhopper.

Egg.—The egg is long, slender slightly curved, and greenish white. It is placed in the stems and veins of the leaves. It may barely be seen with the naked eye.

Nymph.—The young leafhoppers or nymphs are smaller than their parents and they resemble them in general form, but they do not have wings. After hatching from the egg they pass, by shedding their skin, thru five growth stages before they are full-grown.

Adult—The adult sugar-beet leafhopper is pale green or cream-colored. The over-wintering forms are often spotted with darker marks. The insect is about $\frac{1}{8}$ inch in length and the wings are held roof-like over the body (Fig. 1). The mouthparts are adapted for sucking sap from the plant in both the nymph and full-grown leafhopper forms.

Life History.—Female leafhoppers (Fig. 1) appear in beet fields in the spring and place their eggs in slits cut in the mid-ribs of the leaves or in the petioles of the sugar-beet. These females continue to deposit eggs at intervals during the entire summer, but the oviposition is heaviest during July. One female has been known to deposit a total of 247 eggs. These eggs hatch in 10 to 15 days under favorable weather conditions, and the young leafhoppers (nymphs) become full-grown in from 20 to 25 days. The males and females mate, after which the males soon die. The females after feeding on sugar-beets all summer go to other host plants or seek a protected place to pass the winter. There is probably only one brood a year in Utah,

²*Atriplex argentea*

⁶*Salsola pestifer*

¹⁰*Convolvulus arvensis*

³*Atriplex canescens*

⁷*Amaranthus retroflexus*

¹¹*Erodium cicutarium*

⁴*Atriplex rosea*

⁸*Amaranthus graecizans*

¹²*Sarcobatus vermiculatus*

⁵*Chenopodium album*

⁹*Solanum nigrum*

but in some parts of California it is reported that there are from two to four.

Habits of the Leafhopper.—Climate has a marked effect on the behavior of the sugar-beet leafhopper. In the warmer beet-growing sections of California the insect feeds actively on weeds thruout the winter and is ready to return and feed on beets the following spring. It is doubtful if the insect ever lives thru normal winters in large numbers in the beet-growing valleys of Utah. If a few do live thru, they must do so in a dormant condition in some protected place. However, if any of these leafhoppers lived thru the winter with the curly-leaf disease in their body they might start the infection in beet fields before other leafhoppers migrated into the fields.

It is believed that the infestations that suddenly appear in the Utah beet fields are the result of migration of the leafhoppers by flight from their native host plants in desert areas. Ball believes that the Escalante Desert is one of the principal breeding grounds. It is known that plants in other desert areas also have many leafhoppers. The insects are thot to breed on these desert plants and then, due to overcrowding or drying up of their food supply, they start to migrate in large swarms. These swarms have been seen by Ball in mountain passes at an elevation of 7000 feet, on Beaver Mountain at 12,000 feet, and on Pike's Peak at a height of 14,000 feet. When they suddenly appear in valleys where sugar-beets are cultivated, it is largely a matter of chance just where they settle down. Fields in one section may be seriously damaged while others a few miles away are comparatively free from the pests. The leafhoppers, when once settled, do not move to other plants as long as their food supply remains fresh. For this reason the disease does not often spread to new fields during midsummer. The insects appear first on beets during early June in northern Utah and sometimes a month earlier in the Sevier County beet fields. This is about the time that the first beets are being thinned. Ball reports that there may be several swarms during the summer to increase the number from the first migration but that usually there is only one flight. Beet fields in which the beets are not yet up when the leafhoppers make their first flight are often free from leafhoppers the rest of the summer.

These leafhoppers with their sucking mouthparts remove the sap from the beets and at the same time transmit the curly-leaf disease to the beet. Leafhoppers do not inherit curly-leaf from their parents and not all leaf-hoppers can transmit the disease. There is some evidence that leafhoppers are not able

to transmit the disease for some hours after they become infected. To transmit the disease the leafhopper must first have fed on a diseased beet or on some other plant that has the curly-leaf disease. A disease-carrying insect can infect a beet by feeding on it from one to 20 minutes. The symptoms of the disease do not usually show up in sugar-beets for a period varying from 7 to 14 days after infection. When a leafhopper is once infected it has the power of spreading the disease during its feeding for the rest of its life. It is known that certain of the weed-hosts of the leafhopper are also subject to curly-leaf disease. Leafhoppers, reared for their entire life on Russian thistle, rough pigweed, tumbleweed, lowland purslane, black nightshade, and stork's bill, have transmitted the disease to sugar-beets in experimental work carried on in California by Severin. Titus reports that lamb's quarters may also become infected. It is evident then that a leafhopper may bring curly-leaf to a healthy beet either from diseased beets or diseased weeds. At harvest time these infected leafhoppers leave the beets for some other host plants. Eventually they seek hibernation around these plants, but it is doubtful if many live thru until spring in Utah.

Factors Influencing the Damage from Curly-leaf Disease.—

To have curly-leaf in beet fields it is necessary to have leafhoppers infected with the disease. It is said in California that one infected leafhopper to every twenty beets at thinning time is enough to make the crop a failure. If beets have reached a good size before they are infected, they usually survive the disease. If beets are small when they become infected they usually succumb to curly-leaf. The damage from curly-leaf is greater when the weather is dry and hot. The migration from the desert host plants is larger in dry seasons and the beets have less resistance to the disease. Beets on light, sandy soil are affected more than those on heavier soils because of the higher temperature. Beets that are watered early in the growing season and that continue to be watered at frequent intervals suffer less from curly-leaf than those that are allowed to become dry. Beets should not be so dry that they will wilt from the heat in the middle of the day. They are very susceptible to curly-leaf in this condition. The effect of heat on the presence of curly-leaf may also be seen in fields that have hedgerows or trees along one side that shade part of the field and thus make the soil temperature lower. Beets in this part of the field are less damaged by curly-leaf. For the same reason weedy fields are less injured than those that are clean cultivated. The weeds shade the ground. The summer of 1924 was hot and dry

thruout the beet-growing area of Utah. In some cases sufficient water for proper irrigation was not available, and for the first time in several years the disease was noticeably injurious.

Control.—When more is known in regard to the winter habits and the source of migrations of the sugar-beet leafhopper, it may be possible to predict the flights into the beet-growing valleys of Utah. If the desert breeding grounds were thoroly known and if these grounds were inspected from time to time to see if leafhoppers were unusually abundant, it might be possible to tell when there would be a leafhopper migration. Inspection of this kind is said to have been carried on with some small degree of success in California. In addition to a study of desert breeding areas, there are two lines for future research that may result in preventing the injury of the leafhopper to the sugar-beet. The leafhopper may be killed or a strain of sugar-beets that is able to resist the curly-leaf disease may be developed. Several men are working on this last possibility, and some day we may have developed a sugar-beet which the disease will not affect. To kill the leafhoppers when they first appear in the fields is a difficult task. A partial control has been obtained in California by dusting the plants with nicodust, a powder made by treating lime, sulfur, or gypsum with nicotine sulfate. The insects on the plants are killed by the nicotine vapor that is set free. This material would have to be applied when the leafhoppers first appeared and because of the short feeding period necessary to start the disease, only a partial control could be expected. It is doubtful whether this would be practical under Utah conditions. Another method of destroying the leafhoppers is by the use of parasites. Parasites are insects that feed on other insects and kill them. C. F. Stahl working in California has done considerable work along this line. He finds that these parasites destroy many leafhoppers.

If, when diseased plants are first seen, these plants are pulled up and destroyed together with any leafhoppers that may be on them, the spread of the disease will be much slower. It will be necessary for new, infested plants to develop before the disease can be distributed. This process, known as rogueing, is effective only when the disease is first introduced into the field.

At present it is only possible to advise early and frequent irrigation and rogueing the first infected plants.

2.—SUGAR-BEET WEBWORM

The sugar-beet webworm¹³ is of foreign origin. It has been known as a pest in Europe and Asia for many years and is often

¹³*Loxostege sticticalis* Linnaeus

very destructive to beet crops in Russia, Germany, and other European countries. It was found in Utah in 1869, having been introduced by way of the Pacific Coast at some previous time. It is now distributed thru all of the beet-growing sections of western America.

The caterpillars of this insect may suddenly appear in large numbers and devour the foliage of a beet field before their presence is fully realized. So fast do they work that the crop often suffers before beet growers sense their danger and can start control measures.

In the territory of the Great Western Sugar Company in Colorado, 31,000 acres of beets were injured in the year 1918. The loss was estimated by Asa C. Maxson to be 26,400 tons valued at \$264,500. Eighty-four thousand pounds of Paris green were used in an effort to control the pest. Losses of one to five tons per acre and reduction of 2 to 5 per cent in sugar content are common in years of webworm abundance. In the year 1921 some fields were completely destroyed in Benson, Utah. The insect is not injurious every year, but growers should be ready to fight it every year for it may suddenly appear in destructive numbers.

Type of Injury.—The newly-hatched caterpillars eat out shallow patches from the lower epidermis of a beet leaf. They are not able to eat thru the leaf and to produce holes until they are several days old. If the worms are abundant, the entire leaf is destroyed and cavities are eaten in the petioles (Fig. 2, cover cut). In the case of small beets, burrows are also made in the crowns by the feeding caterpillars.

The outside foliage of a beet is attacked first and the young newly-formed leaves are the last to go. If these leaves are destroyed when the beet is still small the plant is often killed outright, but older beets are able to send out a new growth of leaves and they may live, altho growth is stopped while the destroyed foliage is being replaced. It is possible for the tops of the beets in a field to be so completely devoured that only a few ragged petioles are to be seen where three days before there was a good thrifty stand. Only in the caterpillar stage is the insect injurious.

Hosts.—In America the sugar-beet webworm is primarily a pest of sugar-beets, but it has been known to feed on the following cultivated crops: corn, cabbage, currants, gooseberry, spinach, pea, bean, onion, celery, tomato, squash, pumpkin, cucumber, and alfalfa. It may also be found on pigweed, lamb's quarters, and Russian thistle.

Description.—The parent of the sugar-beet webworm is a moth. In its development it passes thru four stages as follows: egg, larva or caterpillar, pupa, and adult (moth).

Egg.—The egg of the webworm is slightly oval, flattened, pearly white, and about $1/25$ of an inch in length.

Larva or caterpillar.—The webworm larva varies from green to almost black. There is a black line down the middle of the back and a broad dark broken line along each side of the body. Between these lines are many small hairs, the bases of which are surrounded by black rings. The lower half of the body of the caterpillar is lighter in color and its length is from $3/4$ of an inch to 1 inch (Fig. 5).

Pupa.—The pupa of the webworm is brown or bronze-colored and about $1/2$ inch in length. In this stage the insect is inactive and makes the change from a caterpillar to a moth in a long silken cocoon. This cocoon is hollow, twice as long as the caterpillar, and so covered on the outside with particles of dirt that it is not easily seen.

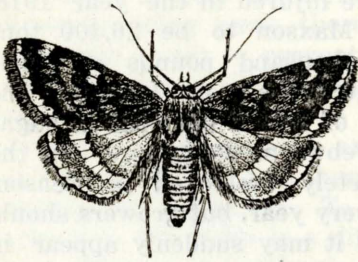


Fig. 3—The moth of the sugar-beet webworm (*Loxostege sticticalis* L.). Enlarged $1\frac{1}{2}$ times.

Adult.—The parent insect of the webworm is a brownish moth with cream-colored markings on the wings (Fig. 3). There is a light cream-colored band just within the outer margin of the forewing and a prominent cream-colored mark just beneath the middle of the front margin. The insect spans about one inch from the tip of one wing to the tip of the other. At rest on the ground or its host plants the insect is inconspicuous because of its resemblance to its surroundings. At rest, it is triangular in outline as the forewings are only partly spread out (Fig. 4).

Life History.—The sugar-beet webworm passes the winter in the ground as a caterpillar within its silken cocoon. In the spring this caterpillar changes to the pupa, a resting stage. The pupa stage also is passed in the cocoon and lasts from 9 to 23 days, depending on weather conditions. At the end of this time the pupa breaks open and the parent moth (Fig. 3) comes out. These first moths may be seen during the last of May or early in June in Cache Valley in northern Utah and earlier than this in the beet-growing sections farther south.

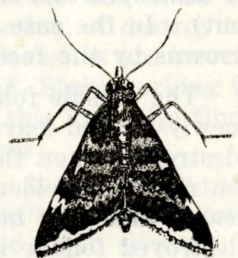


Fig. 4—The parent moth of the sugar-beet webworm with wings in a resting position. Enlarged $1\frac{1}{2}$ times.

After mating, the female moth deposits its eggs on the underside of the beet leaves or on the leaves of some other host plant such as lamb's quarters, Russian thistle, and alfalfa. One female may deposit from 150 to 700 eggs. These eggs may be placed singly or arranged in rows of from 2 to 10, one egg slightly overlapping the one in front of it. Three hundred eggs have been found on one beet plant. The eggs hatch in from 3 to 5 days.

The webworm caterpillars (Fig. 5) feed on the leaf tissue and the summer broods complete their growth in 17 to 20 days. When full-grown the caterpillar ceases to feed, goes into the ground from one-half to two inches, and spins the silken cocoon



Fig. 5—Caterpillar or larva of the sugar-beet webworm (*Lorostege sticticalis* L.) Enlarged 2 times.

in which the change to the second brood of moths is made. In the summer broods, all of the changes from the egg to the adult are completed in from 30 to 40 days. There may be three broods a year in northern Utah.

The first brood of caterpillars, or worms, is present on the beets during July; a second may appear in August; and in some seasons there is the possibility of a small third brood in September. Some of the second brood of worms stay in cocoons thru the winter, and all of the third brood live until the next spring in this way. In some years the broods so overlap that near the end of the season, caterpillars of all sizes may be found in a field at one time.

Habits.—The parent moths of the sugar-beet webworm have a short, jerky flight. They are active in the fields in the day-time and are also attracted to lights at night. Most of their eggs are deposited at night. The moths often migrate in swarms some distance from the field in which they were reared. In this way new fields may be infested.

The caterpillars are voracious feeders. In one day they may eat a quantity of beet leaves equal to several times their own weight. When feeding they may often be found concealed beneath a web of silk that they spin on the underside of a leaf or they may be webbed in among the eaten stems near the crown of the beet. If the feeding process is disturbed the larva will jerk its body back and forth and drop from the plant to the ground. Young larvae often hang from the underside of the leaves on a thread of silk spun thru an opening in their upper lip. If the weather turns cold for about two days just after the eggs hatch, many of the small webworms will be killed.

The number of worms is usually not the same in all parts of a beet field. There are often more in the center of fields than near the margins. The moths like to congregate at breeding time, and they may pick out some small portion of a field as a place to deposit their eggs. A place where the weeds have not been cleaned out is especially attractive. Moths will deposit many of their eggs on lamb's quarters and pigweed, either in a field or in fence corners, and as the caterpillars grow larger and their

food becomes scarce they will migrate to the beets from these weedy portions.

When the food supply becomes scarce the caterpillars often migrate in thousands in search of new feeding grounds. It is said that in Montana the crushed bodies of these migrating throngs have so lubricated the railroad tracks that trains could

not run. If their march brings them to an irrigation ditch they will crawl into the water and many will be destroyed by drowning.

Enemies of Webworms.—

There are many insects and other animals that tend to reduce the number of webworms. This is especially true of the second and third broods.

There are parasitic flies (Fig.

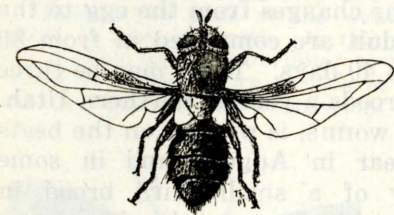


Fig. 6—A fly parasite (*Frontina archippiva* Will.) of the caterpillar of the sugar-beet webworm. Enlarged 4 times.

6)¹⁴ that deposit their eggs on the webworm caterpillars. These eggs hatch into maggots that feed on and kill many of the caterpillars. They are therefore beneficial insects. There are also many wasp-like insects known as Ichneumon-flies (Fig. 7)^{15, 16} that destroy caterpillars in much the same way as do the flies described above.

In the fall of 1921, eleven hundred webworm cocoons containing caterpillars were collected around the beets in an infested field. These were placed in cages in the laboratory. One hundred and fifty-seven moths and three hundred and sixty-four parasites came out of these cocoons. Many larvae died from the unnatural laboratory conditions, but judging from the figures given about 70 per cent of the worms were destroyed by the parasitic enemies mentioned above.

Blackbirds, sparrows, meadowlarks, and quail destroy many webworm larvae and pupae. They destroy them when the worms are migrating in the summer and again when their cocoons are broken open by cultivation in the fall. In one infested field, H. J. Pack found about 100 toads¹⁷ to the acre. Several were taken to the laboratory, killed, and the toads as

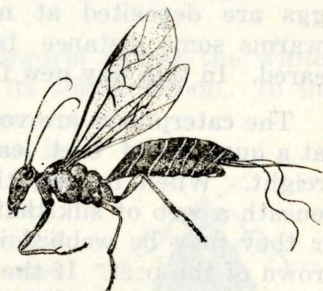


Fig. 7—A hymenopterous parasite (*Bracon vulgaris* Cress) of the caterpillar of the sugar-beet webworm. Enlarged 4 times.

¹⁴*Frontina archippiva* Will.

¹⁵*Meteorus loxostegoi* Vier.

¹⁶*Bracon vulgaris* Cress.

¹⁷*Bufo cognatus* Say

well as the contents of their stomachs were weighed. The stomachs were entirely filled with webworm caterpillars, which made up 15 per cent of the total weight of the toads. It is said that a toad empties its stomach four times in every 24 hours. On this basis these toads would eat in one day an amount of webworms equal to 60 per cent of their own weight.

Control.—The only sure way to kill the caterpillars of the webworm is to poison them as they feed on the beets. Webworms develop so fast and eat so much that serious damage may be done before their presence is realized. For this reason the underside of the leaves should be examined carefully every few days during July and August to see if eggs or caterpillars are present. Since the heavy infestation may be in a few restricted parts of a field, it is advisable to walk thru the beets at intervals and pick leaves for examination. Asa C. Maxson reports that the presence of one or two worms on one-half to two-thirds of the leaves at the time of the first brood may result in a total loss of the crop from later broods.

It is much easier to destroy the worms when they are small. As soon as newly-hatched worms are seen on the foliage the sugar company fieldman should be notified and arrangements made for procuring poison and a sprayer. Paris green sprayed on beets at the rate of 4 pounds to the acre will kill in 24 hours all the worms that feed on the sprayed beets. Traction sprayers of the type used by the sugar companies are most satisfactory, and they are cheap to operate. It is important that the machine should have a good agitator as Paris green is heavy and will settle to the bottom of the tank. If there is any doubt of the number of gallons of spray placed on an acre by the machine used, this may be determined in the following manner described by Maxson:

“Fill the tank with water, put the pump in gear, then drive along the road and measure the distance traveled in discharging all of the water thru the nozzles. Multiply this distance, measured in feet, by the width of the number of beet rows you spray and divide this by 43,560 which is the number of feet in an acre. This will give you the part of an acre you spray with one tank of water.” By this means, the amount of poison, at 4 pounds to the acre that should be used in a tank of spray, may readily be computed. For example, if one filling of your sprayer will cover three-fourths of an acre as determined by the procedure given above, use 3 pounds of Paris green to each tank.

A pressure of at least 80 pounds should be maintained to develop a fine mist spray. Arsenate of lead powder may be used at the rate of 8 pounds to the acre, but it kills more slowly

than Paris green and for this reason is not as satisfactory. Calcium arsenate may also be used at the rate of 6 pounds to the acre. It also kills more slowly than Paris green. If a field is heavily infested a quick killing is necessary. Soap is sometimes added to the poison at the rate of 6 pounds to the 100 gallons of spray to make it adhere to the beet foliage.

Paris green is a strong poison and care should be taken to keep all pails and cans that have contained it away from children and livestock. In handling Paris green a person should be careful not to inhale it. It will irritate the lining of the nose. This poison irritates the skin of some people who handle it and causes a rash to break out. This is especially true if the person has been perspiring. Paris green, tho it burns most plants, seldom, if ever, injures sugar-beets when properly applied.

When the webworm caterpillars are migrating they may be checked if it is possible to turn a stream of water into an irrigation ditch across their line of march. Any that enter the water will be drowned. Another check that has been recommended is to place in front of the migration a bait of freshly-cut alfalfa or lamb's quarters poisoned with Paris green at the rate of one pound of the poison to each 50 pounds of the green food.

There are certain cultural practices that also help in the control of webworms. If any of the weed host plants such as lamb's quarters are allowed to grow in fence corners and along ditch banks, they may act as a starting ground for a migration of the webworms. These should be cleaned out or sprayed to destroy the worms.

If fields are plowed or disked in the fall many of the silken cocoons will be broken open. Some of the caterpillars will then succumb to the cold or be buried so deeply that the moths cannot emerge. Caterpillars left uncovered on the surface of the ground are often destroyed by birds. Irrigation during a webworm infestation, or just following, will help the plants to recover and replace the destroyed foliage.

Many moths have been caught by the use of a trap light. A lantern is placed in a pan filled with water and with a thin film of kerosene oil on top. The moths attracted to the light are caught and held by the film of oil. One grower reported that he caught one gallon of moths in three nights by using several of these lights in and near his beet field. Trap lights alone should not be relied on to control an outbreak of webworm. Some of the moths that will be caught in this way are males, and many of the rest are females that have already placed their eggs on the beet leaves. It is only when females that contain eggs are captured that the lights are a success.

3.—SUGAR-BEET ARMYWORM

The sugar-beet armyworm¹⁸ is an insect that is found in many parts of the world. It occurs on all of the main continents and, as would be expected of an insect living under this wide range of conditions, it is a pest of many cultivated plants. In North America it is found in the Rocky Mountain and Pacific Coast states. It was probably introduced from Asia sometime before 1876, but it was not given much attention or regarded as a pest until 1899 when it began to injure sugar-beets in Colorado and New Mexico. In 1908 it became destructive in the beet fields of Utah, and since this date it has appeared from time to time and injured fields in most of the beet-growing sections of the state.

Hosts.—The caterpillar of this insect is known to feed on garden beets, sugar-beets, corn, potatoes, peas, beans, onions, cotton, and alfalfa among cultivated crops. It will also feed on lamb's quarters, pigweed, saltbush, mallow¹⁹, Russian thistle, sunflower²⁰, and certain field grasses.

Type of Injury.—The very small caterpillars skeletonize the leaves of a sugar-beet. They feed on the leaf tissue, but as they leave the veins the leaf is given a network appearance. As these worms become larger they devour large portions of the foliage in much the same manner as the sugar-beet webworm. Like this last-named insect, they may also eat into the crown of the beet, and in some cases they feed on the beet below the surface of the ground.

Description.—The sugar-beet armyworm passes thru four stages in its development: egg, larva or caterpillar, pupa, and adult (moth).

Egg.—The egg is pyramidal in shape when viewed from the side. As seen from above, it is round. There is a pointed cap separated from the lower part of the egg by an indented white line. Eggs are deposited in groups and covered with gray down.

Larva.—The prevailing color of the caterpillar is green with a broad, gray or black band bordered above with white running along each side. In some forms this line is prominent; in others it is almost wanting. The length is from 1 to 1½ inches when full-grown (Fig. 9).

Pupa.—The pupa is brown and bears two slender spines on the posterior end. It is found in cells made of compacted dirt in the soil near the host plants.

Adult—The parent insect is a gray-brown, heavy-bodied moth spreading from 1 to 1½ inches. The front wing bears two large light-colored spots near the front margin. The hind wing is nearly white, except for a border of dark scales on the outer edge (Fig. 8).

¹⁸*Laphygma exigua* Hübner

¹⁹*Helianthus annuus*

²⁰*Malva rotundifolia*

Life History and Habits.—The sugar-beet armyworm is believed to pass the winter as a moth (Fig. 8) hidden away in protected places. In the spring these moths come from their winter quarters, mate, and the females search for a place to deposit their eggs.

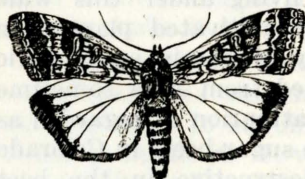


Fig. 8—The parent moth of the sugar-beet armyworm (*Laphygma exigua* Hübner). About natural size.

If beets are available, the eggs are placed on the underside of the leaves, but many of the eggs of the overwintering moths are deposited on some of the many weed hosts. One female will deposit several masses of from twelve to fifty eggs each. These eggs hatch in four or five days and the young caterpillars coming from these eggs feed in colonies on the leaves. The under-surface is the preferred feeding ground, but they are occasionally found on the upper side. Sometimes the young caterpillars spin a web under which they feed. There may be three or four under the same web. When about half-grown they feed openly on the foliage and are at this time preyed on by crows and predaceous insects. When all of the succulent food material is gone they migrate, as does the sugar-beet webworm. On this march they are able to travel at the rate of two to three feet per minute. When migrating they feed on many cultivated crops other than beets and have even been known to climb apple trees and feed on the leaves. The larva or caterpillar stage lasts for a least two weeks and often much longer.



Fig. 9—The caterpillar or larva of the sugar-beet armyworm (*Laphygma exigua* Hübner). Slightly enlarged.

When full-grown the caterpillar (Fig. 9) enters the soil near a beet to a depth of about one inch and turns to the yellow-brown pupa within an earthen cell. The insect remains in this stage for about two weeks.

There are apparently two broods of caterpillars a year in Utah and Colorado, but it is said that there may be three in California. The first brood of caterpillars is often found on the beets in June, about thinning time. In the summer of 1924 worms of all sizes were found in certain beet fields near Provo, Utah, during the first week of June. The second brood is the one that is reported to be most destructive. It usually occurs during August, but in Utah the second brood is often smaller than the first brood. There is a great variation in the size of the worms in a field. Newly-hatched and full-grown forms may be feeding side by side. This is partly because a moth takes eleven

days or more to deposit all her eggs, and partly because some moths mate and are ready for oviposition earlier in the season than others.

Plants should be inspected from time to time to see if eggs or caterpillars are present. Since the insect has many weed hosts, the caterpillars may migrate from weeds along fences or ditch banks to beet fields. It is not uncommon to find an infestation of the webworm and the armyworm in the same field. Their feeding habits are very similar.

Control.—This insect may be controlled by spraying with Paris green as recommended for the sugar-beet webworm. When the worms migrate they may be destroyed by the interposing of irrigation water or putting out baits as advised for the webworm.

4.—GRASSHOPPERS

Grasshoppers are old pests. They are mentioned in the ancient literature of the Greeks and Egyptians as well as in biblical writings. There is evidence that the Aztecs and Indians had to contend with them long before the time of the white man. In the years from 1743 to 1756 they destroyed many of the crops of the early New England colonists. As settlement spread westward and new lands were developed, grasshoppers changed their habits to fit the new conditions and added greatly to the hardships of the early settlers in most of the western states. In the years 1875 to 1877 settlers in western Minnesota and other middlewestern states had nearly all of their crops destroyed by a grasshopper known as the Rocky Mountain locust. These insects migrated from their breeding grounds in millions. They flew high in the air in swarms so large that they are said to have shut off the light of the sun. Wherever they came to earth they would feed on any green vegetation that they could find. It is said that they would sometimes pile up three and four deep on a plant, struggling among themselves to get near enough to use their jaws. In beet fields after the foliage was destroyed, they would fight for a chance to crawl down into the ground to feed on the taproots. They were so numerous that in one day they could destroy all of the growing crops in a region. Two or three days after their arrival they would mount in the air and depart as quickly as they had come, leaving barren fields and disheartened pioneers behind them. It has been a long time since a destructive outbreak of the Rocky Mountain locust has occurred. In fact no one has been able to find a specimen of this grasshopper for many years, and it is doubtful if it will ever be seen again in large numbers. However, we do have other grasshoppers that cause great

destruction to our crops in Utah. They are not a serious pest every year, but when conditions are right they may appear in immense swarms and destroy every green thing that may serve them as food. After one destructive season they may again disappear and not reappear for several years.

There are two general classes of grasshoppers—the migratory and the non-migratory types. The migratory type is illustrated by the Rocky Mountain locust described above, by the warrior grasshopper, and to some extent by the lesser migratory grasshopper. The non-migratory type does not move in large bodies nor for long distances, tho it may travel a short distance in search of new food. The two-striped grasshopper and the red-legged grasshopper are of this type. The behavior of all of these forms is similar in most particulars, and for this circular only a general discussion of the life history and habits of grasshoppers as a group will be given.

Injurious Grasshoppers.—There are many kinds or species of grasshoppers, but relatively few of these are pests of cultivated crops. The following are the forms usually injurious

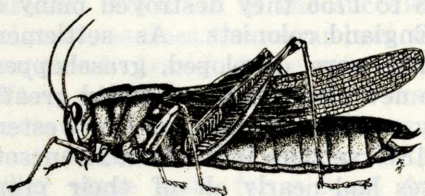


Fig. 10.—A grasshopper often injurious to sugar-beets (*Melanoplus bivittatus* Say). Slightly enlarged.

to sugar-beets in Utah: The two-striped²¹ or two-lined grasshopper (Fig. 10) is one of the most common offenders. This species may be recognized by two yellow lines that begin near the eyes, extend lengthwise on the back and meet near the tip of the wings. It is

from one inch to one and one-half inches in length. The lesser migratory grasshopper²² is a smaller form that is often injurious. It is yellow, brown, or gray in color and about one inch in length. The legs are spotted with black and yellow marks and the tibia, or long slender portion of the hind leg, is reddish or bluish. On the back just behind the head a large, dark area is usually found. This species is migratory. The red-legged grasshopper²³ is similar to the lesser migratory grasshopper in appearance, but it is not migratory in its habits. The warrior or pellucid grasshopper²⁴ is about one inch in length, usually gray or brown in color, with black spots on the wings, and a black spot behind the eye and on the collar. There is also a ridge down the middle of the collar. The shaft of the hind leg is yellow. This form migrates in immense swarms. Still another

²¹*Melanoplus bivittatus* Say

²²*Melanoplus atlantis* Riley

²³*Melanoplus femur-rubrum* De Geer

²⁴*Camnula pellucida* Scudder

form that is often present in beet fields is the black-winged grasshopper or Carolina locust²⁵. This is a brown or gray form that may become from 1 ¼ to 2 inches in length. It is very inconspicuous when it is at rest with its wings closed, but when it flies it attracts much attention because of its black hind wings with their bright yellow border.

Type of Injury to Beets.—Grasshoppers have biting jaws. Both the nymphs and full-grown forms chew their plant food. They will feed on the leaves of a sugar-beet until the entire top is destroyed. Often they will feed on the crown of the plant and kill it by preventing the production of a new growth of leaves when the first ones are destroyed. Other crops are attacked in much the same way.

Life History and Habits.—Most grasshoppers pass the winter in the egg stage. These eggs are placed in a hole in the ground by the female grasshopper (Fig. 11). She uses the four horny points on the end of her body as a drilling organ in making the hole. The eggs are surrounded by a protecting sticky secretion given off by the grasshopper when the eggs are deposited. Grasshoppers prefer dry, warm, over-grown places for egg-laying. Hard ground with few roots in the top-soil is

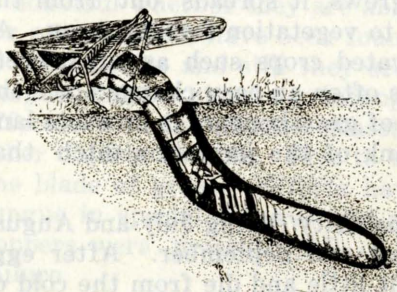


Fig. 11.—A grasshopper depositing its eggs in the ground.

favorable. Fence rows, ditch-banks, weedy pastures and dry grazing grounds are common breeding places. Eggs are not deposited in any quantity in fields used for cultivated crops such as peas, corn, or sugar-beets, nor in well-kept alfalfa fields. Some grasshoppers, such as the warrior, migrate until they find just the right place to deposit their eggs. In the case of this species, Ball reports that they pack the top soil so thick with eggs that if the ground is scraped with a shovel little but eggs will be found. Each female grasshopper usually deposits two, and sometimes three, egg-pods or capsules. There may be from 18 to 70 or more eggs in each of these pods. The number varies with the different grasshoppers. It may be said then that a grasshopper may deposit a total of from 40 to 150 or more eggs. If the eggs are able to withstand the cold of winter and the

²⁵*Dissosteira carolina* Linnaeus

moisture of the early spring months, they will hatch during May and June into young grasshoppers or nymphs (Fig. 12). These small forms resembled their parents except in the absence of wings and in the fact that the head is larger in proportion to the rest of the body than it is in the full-grown form.

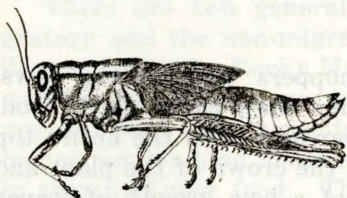


Fig. 12.—A partly-grown grasshopper or nymph (*Melanoplus bivittatus* Say). Enlarged about twice.

Young grasshoppers do not eat much when they first hatch out. On sunny days they will nibble a little on plants near their hatching ground and at night and in damp weather they will roost on the surrounding vegetation. Young grasshoppers thrive in warm, hot weather. A cold, wet spell soon after hatching will result in the destruction of many of them.

A grasshopper will be full-grown in four to six weeks after hatching from the egg. As it grows, it spreads out from the vicinity of the breeding grounds to vegetation farther away. At this time it often goes to cultivated crops such as sugar-beets and feeds on the foliage. This is often an easy change since the breeding ground for many kinds of grasshoppers is in waste land such as fence corners or the bank of the irrigation ditch that feeds these fields.

Grasshoppers usually reach maturity during July and August and deposit their eggs in August and September. After egg-laying the parent insects feed but little and die from the cold of winter if they have not perished before. There is but one brood a year in all of the injurious forms.

Enemies.—Grasshoppers have many enemies that tend to keep down their numbers. Birds are important in this respect. Hawks, owls, blackbirds, sparrows, wrens, robins, crows, woodpeckers and even the magpie are mentioned as birds that prey upon grasshoppers. One bird that is especially beneficial in Utah is the California gull. This bird was a great benefit to the early settlers, and it still destroys many grasshoppers and other harmful insects. In a trip to the breeding grounds of this gull on Bird Island in Great Salt Lake in July 1924, the writer had the opportunity of seeing the stomach contents of several of these birds. Their food was almost entirely insects and consisted largely of grasshoppers.

Chickens and turkeys will feed on grasshoppers and they often destroy many. However, it is not wise for a farmer to trust entirely to these birds to protect his crops. In some cases

chickens and turkeys have apparently held the grasshoppers entirely in check, but they cannot usually be relied on to make a complete clean-up in large infestations. Lizards, snakes, and toads also catch and destroy many grasshoppers.

There are many insects that prey upon grasshoppers. Certain flesh-flies deposit eggs or living maggots on the body of a grasshopper. The maggot makes its way into the body of the grasshopper and feeds on the juices and tender tissues and eventually kills the insect. Robber flies insert their strong sucking beaks into grasshoppers and suck their blood. Wasps paralyze them with their stings and then carry them to their nests as food for their young. The larva, or immature stage of the blister-beetle (Fig. 21), feeds on the eggs of grasshoppers. Tho many eggs are often destroyed in this way, the total benefit to the farmer is questionable since the parent blister-beetle feeds on sugar-beets and other crops. There is a small red mite that is often seen clinging to the wings and bodies of grasshoppers. It is doubtful whether they are able to do much harm to the insect for grasshoppers have been found with 50 to 100 mites attached to their bodies and still they seemed in a healthy condition. A fungous disease attacks grasshoppers during late summer. When affected with the disease, grasshoppers climb on grain, grass or other objects and die. Five to ten dead bodies will be found on one blade of grass. Efforts have been made to cultivate this fungus in special cultures and spread it in places where grasshoppers were present. All of these efforts have met with failure.

It is seen from the long lists of parasites and predators given above that many kinds of animals help to keep down the numbers of grasshoppers that may be present each year. Given favorable weather at hatching time and a shortage of the enemies mentioned above, and damage from the feeding of grasshoppers is to be expected.

Control.—One of the most important preventatives against grasshopper outbreaks is to destroy the eggs in the ground before the time for them to hatch in the spring. Since grasshoppers seek out as breeding grounds dry, weedy places in poorly-kept pastures and along fence rows or ditch banks, these places should be examined, and if many eggs are found the place should be plowed or disked and harrowed. If the land containing the eggs is to be planted to crops, plowing is enough. If it is not to be planted, a thoro disking or harrowing to a depth of a few inches will break open many egg-capsules, destroying some eggs and leaving others open to the attacks of predaceous birds and insects. These eggbeds should be disked in two or three direc-

tions in the fall. This should be followed by one or two treatments the following spring. Eggs in fence corners where they cannot be reached by cultivation should be dug out with a grub hoe. Destroying the eggs is the most important operation in the control of grasshoppers when it can be done. Ball found that the warrior grasshopper sought out special places to deposit its eggs. By cultivating these places a severe outbreak of several years' standing was quickly checked. Ball also found that it was necessary when dealing with the warrior grasshopper to locate these breeding areas and to have someone stake out the eggbeds for future treatment. In all grasshopper control work there must be a united effort of the entire community if the campaign is to be a success.

If the eggs of the grasshoppers are not destroyed, the newly-hatched nymphs may be killed by spraying with kerosene, crude oil, or some material that kills by contact. A brush drag weighted with stones may also be used. Utah Experiment Station Bulletin No. 138, written by E. D. Ball, will give more detail in the control of the warrior as well as other grasshoppers.

If the eggs of grasshoppers have not been destroyed, the insects should be killed with the poison-bran bait. The formula for this follows:

Bran (free from shorts).....	100 lbs.
Sodium arsenite (weed killer).....	1 or 2 pts.
OR	
White arsenic.....	4 or 5 lbs.
Sugar-beet molasses.....	2 gals.
Amyl acetate.....	3 oz.
Salt.....	5 lbs.
Water.....	9 to 11 gals.

In some cases sawdust may replace bran in the bait or may be mixed with it—half and half. If this substitution is made, it has been found wise to replace the bran with the sawdust by **bulk** rather than by **weight**. For example, if normally a 100-pound sack of bran would be used, a sack of the same size filled with sawdust should be used in the substitution.

Sodium arsenite (weed killer) has given good control in almost all places where it has been used. It has the advantage of being cheaper, killing more quickly, and of mixing more easily than white arsenic. When grasshoppers are full-grown 2 pints to the 100 pounds of bran should be used. Young grasshoppers or nymphs may usually be killed by one pint to 100 pounds. When used in the above formula, a grade of sodium arsenite should be used that contains eight pounds of arsenious oxide to the gallon. Five pounds of crude white arsenic is usually considered equal to four pounds of the refined product. Either

grade should give good control, if sodium arsenite is not obtainable.

The addition of salt is favored, especially when grasshoppers are full-grown at the time of poisoning. If the soil is alkaline, a bait is better without salt.

The use of amyl acetate, as a substitute for oranges and lemons which have been extensively used, is almost universal now. It is much cheaper and equally attractive to the grasshopper. It is important to have a good grade of amyl acetate. The grade "Technical No. 1" is usually the one used. Some brands that are classed as banana oil or bronzing liquids contain little amyl acetate and have impurities that may repel rather than attract the grasshoppers. There is no advantage in increasing the amount of amyl acetate above that given in the formula. In fact, it has been shown by experimental work that when too much is used it acts as a repellent. If grasshoppers are abundant and amyl acetate cannot be obtained, use the bait without it—but use 20 to 30 oranges or lemons. A bait without either amyl acetate or fruit is better than no treatment.

Poison bait should be put out late in the evening or early in the morning. If the outbreak is in an extremely dry place, morning is better so that the bait will not dry out before the insects start to feed. Most grasshoppers feed from about 9 in the morning until noon after they are thoroly warmed up by the sun. Some species also feed for a short time in the afternoon. It may be several days before the effects of the poison are seen. This is especially true when grasshoppers are full-grown and not feeding heavily. Since young hoppers are killed so much more easily and quickly than the full-grown ones, a drive should be started at the first hint of their presence in large numbers. It is often necessary to make several applications of the bait before an infestation is under control.

There are two means of catching grasshoppers that have given good success. One is to use a hopperdozer which consists of a large pan containing water with a film of oil on top. This is drawn on runners thru the field. The insects fly against a shield and are killed when they strike the oil. The second method is to use the grasshopper catcher, developed by E. D. Ball, in which the insects are caught in a large cage. Thirty or forty bushels of hoppers have been caught on one day with this catcher. Literature in regard to these machines will be furnished on request.

The Black or Mormon Cricket²⁶.—This large wingless form is closely related to the grasshopper, and control measures

²⁶*Anabrus simplex* Hald.

against grasshoppers will also be effective against the Mormon cricket. It has been found by experimental work in Colorado that the insects should be poisoned in the breeding grounds while still small. After they are half-grown and are migrating it is difficult to kill them. The bait used for grasshoppers with the substitution of three pints of sodium arsenite instead of one or two is advised. One hundred pounds of bait should treat 10 to 15 acres.

5.—BEET OR SPINACH LEAF-MINER

The beet leaf-miner²⁷ has been known as a pest in this country since 1880. It is of general distribution in both the United States and Canada, as well as in many parts of Europe. In 1891 the beet crop of California was greatly damaged. In 1922 it appeared that the crop in Utah might suffer considerable loss because of the destruction of nearly all of the early leaves. However, in the case of fields under observation during this year, the plants were able to put out a new growth of leaves and to continue their development without a serious setback. This insect is especially annoying when beet tops or spinach are eaten as greens. The white worms floating to the top of the dish as the plants are boiling is annoying to many housekeepers, and the occasional finding of a worm as the prepared dish is being served always raises a question as to how many may have already been eaten.



Fig. 13.—The leaf of a sugar-beet that has several mines made by the beet leaf-miner.

Hosts.—The maggot of the leaf-miner works in the leaves of spinach, table beets, sugar-beets, mangles, chard, and lamb's quarters. Spinach and lamb's quarters are especially attractive to the insect.

Type of Injury.—The newly-hatched larva or maggot of a leaf-miner makes a hole in the outer covering or epidermis of a leaf and feeds on the pulpy filling or parenchyma. The maggot lives within the leaf and is held in place above and below by the epidermis. As the maggot eats out the green tissue a white spot is made in the leaf—tortuous or thread-like at first, but later appearing as a large irregular-shaped blotch (Fig. 13). The leaves droop and wilt in warm weather more readily than do the leaves of un-

²⁷*Pegomyia hyoscyami* Panzer

affected plants. This insect is especially serious when it appears in large numbers in the beet foliage during the late summer. Injury to the foliage at this time results in a reduction in the size and the sugar content of the beet.

Description.—The beet leaf-miner in its development passes through four stages: egg, larva or maggot, pupa, and adult (fly).

Egg.—The egg of the beet leaf-miner is white, cylindrical, and about $1/28$ inch in length. Eggs are deposited singly or in groups of two to six on the underside of the leaves of beets or other host plants.

Larva or maggot.—The larva is white or yellowish and almost transparent. After it has fed the green food may be seen within the body. The maggot is headless, footless, and tapers from the truncate rear end to the head (Fig. 15). There are two small black hook-like jaws that may be withdrawn into the head when not in use. Just back of the head on about the third segment is a pair of spiracles or breathing pores with eight lobes. As it grows the larva sheds its outer skin twice.

Pupa—The pupa, or resting stage, is spent in a puparium—a brown covering made of the last shed skin of the maggot. This puparium is oval and about $1/5$ inch in length. It may be found in the ground beneath infested leaves.

Adult.—The parent insect of the leaf-miner is a gray fly (Fig. 14) with its body covered with long stiff bristles. It is about $1/4$ inch in length with the legs brownish-yellow except for the black tarsi or feet. The face of the fly between the large brownish-black eyes is white. The fly usually carries the abdomen bent downward or curved under its body.

Life History.—A leaf-miner passes the winter in a resting stage in a brown puparium or protective coat in the soil beneath its host plants. In the spring about the last of May, the parent fly (Fig. 14) breaks open the puparium and crawls to the surface of the ground. The males and females mate, and the female places her eggs on the underside of the beet leaves or on the leaves of lamb's quarters if the beets are not yet up. The eggs (Fig. 16) are deposited singly or in groups of two to



Fig. 14.—The parent fly of the beet or spinach leaf-miner (*Pegomya hyoscyami* Panzer). Enlarged 3 times.

six. Nearly every leaf has a few eggs. The fly seems to realize that it is better to scatter her eggs over many leaves so that her offspring may have an abundance of food. The eggs hatch in about four days, and the small maggot (Fig. 15) at once eats a hole thru the surface of the leaf and crawls within. Its entire life is spent within the leaf, between the upper and lower surfaces. The leaf will show white spots where the maggots have



Fig. 15.—The maggot of the beet leaf-miner (*Pegomya hyoscyami* Panzer). It lives within the leaves of sugar-beets. Enlarged 4 times.

been feeding (Fig. 13). There may be several maggots in a leaf, and as they eat out the leaf tissue the burrows may run together, and several worms are sometimes found in one large cavity. If there is no available food left in one leaf the maggot

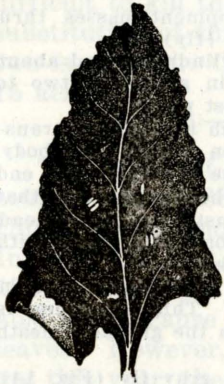


Fig. 16.—Eggs of the beet leaf-miner on the underside of a young sugar-beet leaf.

will leave that leaf and seek another. When the maggot is full-grown it drops to the ground and crawls below the surface to a depth of two or three inches and there changes to the pupa within its protecting case. After a period of time ranging from ten to twenty-five days the fly comes out. In the summer, the time from egg to adult covers at least one month. There are reported to be at least three broods in New York and the same number in Maryland. There are probably three broods in Utah, but they have never been carefully watched. Contrary to the reports from some places, the spring brood, which is present in the leaves about thinning time, is the most destructive one in this state.

Enemies.—A small Ichneumon-fly²⁸ has been reared in large numbers from leaf-miners of the spring brood that have been collected in the beet fields of Cache Valley. Counts have shown that 60 to 80 per cent of the maggots are sometimes parasitized. This is believed to be one reason why there are so few of these insects during the later broods each season.

Control.—Since the maggot of the leaf-miner works within a beet leaf, it is protected and cannot be reached by an insecticide. There is no good way of destroying the pests in a beet field. In a small garden the leaves that contain miners may be picked and destroyed. If lamb's quarters is cut off and destroyed about every two weeks it will prevent maggots maturing in it. Deep fall-plowing has been advised but is of doubtful value as the flies seem to be able to emerge even if the puparia are buried very deep. In some cases a trap crop of spinach is said to keep the flies from depositing their eggs on beets.

6.—FALSE CHINCH BUG

The false chinch bug²⁹ is a pest of general distribution, but it is particularly active in the semi-arid region of the Rocky

²⁸*Opius pegomyiae* Gahon

²⁹*Nysius ericae* Schilling

Mountains. It should not be confused with the true chinch bug, a destructive grain pest that does not occur in Utah. The false chinch bug will suddenly appear in large numbers in a sugar-beet field or on some other cultivated plant and destroy the entire crop in one or two days if energetic action is not taken against it. It appears in beet fields and the gardens of Utah from time to time and is responsible for considerable damage to some crops. In the summer of 1924 it was destructive in parts of at least four counties of the state, but in none of these places was it of general distribution.

Type of Injury.—This insect is a sucking form. It feeds by puncturing a sugar-beet leaf with the bristles of its mouthparts and then sucking the sap into its stomach for food. In addition to the sap that is removed and the consequent weakening of the plant, the infested leaves, if not killed outright, will wilt, become ragged and full of irregular holes. These small insects will also feed on and injure the fruit of strawberries. Sometimes they collect in large numbers on small cabbage plants and remove so much sap that the leaves drop off.

Hosts.—The false chinch bug is a rather general feeder. It feeds on many cultivated plants such as cabbage, carrots, radishes, turnips, corn, cotton, strawberries, raspberries, potatoes, sugar-beets, some grains, and grape and apple foliage. Some of the other hosts are pepper grass³⁰, shepherd's-purse³¹, Russian thistle, purslane³², sagebrush³³, and lamb's quarters.



Description.—The false chinch bug passes thru three stages in its development: egg, nymph, and adult or full-grown bug.

Egg.—The egg of this insect is curved like a new moon, pink, and about 1/16 of an inch in length.

Nymph.—When the insect leaves the egg it is a small form that resembles the full-grown bug very closely, except that it does not have wings (Fig. 18). As it grows it sheds its outer skin several times, and each time little outgrowths or wing-pads that will eventually develop into wings become more conspicuous.

Adult.—The upper side of the full-grown insect is gray with small black spots. The underside is black. The wings are a transparent white and rest flat on the back with the ends overlapping. The insect is about 1/8 inch in length (Fig. 17.)

Life History and Habits.—The false chinch bug is said to winter either in the egg or nymph stage. After reaching ma-

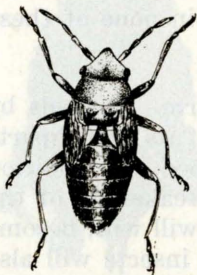
³⁰*Lepidium apetalum*

³¹*Capsella bursa-pastoris*

³²*Portulaca oleracea*

³³*Artemisia tridentata*

turity the insects mate and the females seek a place to deposit their eggs. In the spring and fall the eggs are usually deposited in cracks in the soil or in pulverized ground. During mid-summer these eggs are placed in the heads and blossoms of the weeds on which the insects feed. When egg-laying is over the insects soon die off. These eggs hatch into the wingless nymphs that may be found crawling over the leaves of their hosts and



sucking out the sap for their food. There are several broods of the insect during the summer (probably from three to five in Utah), tho there are said to be as high as seven some years in Kansas. It takes the egg about four days to hatch, and it is about twenty days more before the nymphs turn to the full-grown winged bugs. There may be a new generation about once each month during warm weather.

Fig.18—False chinch bug that is not full-grown. Note the small pads that will develop into wings. Enlarged 8 times.

Tho young bugs or nymphs (Fig. 18) are wingless, yet they may migrate for some distance from the plants on which they hatch out. In one case they were found marching along a concrete irrigation canal in mass formation. If an infested plant is shaken, the nymphs will drop to the ground and then crawl in all directions in search of another plant. The full-grown bugs (Fig. 17) have wings and they often migrate by the thousands to other plants. This is especially true when their weed hosts are destroyed or when they dry up. It is in this way that beets and other cultivated crops become infested. When they reach a new food supply, for example a beet field, they will collect in large numbers on a few plants or perhaps in one part of the field and carry on their intensive feeding until these plants wilt or are killed. They will then attack fresh plants and repeat their destruction. During hot days or in the hotter part of a day, these insects sometimes collect for shelter beneath clods of earth or under the leaves of their food-plants. For some inexplicable reason thousands of the bugs are reported at one time to have collected on an old discarded mattress that was thrown out in a yard. In the spring when food is short, these insects sometimes attack sprouting vegetables, such as squash and cucumbers, just as soon as they crack the soil. It is reported that they will even work down into the soil to meet the upcoming sprout.

The false chinch bug sometimes develops a carnivorous habit. It is reported to attack other bugs and suck their blood

for food. The true chinch bug in Kansas is sometimes attacked by the false chinch bug in this way.

Control.—The false chinch bug may be killed on its weed hosts before migrating to cultivated crops. It may also be killed on beets or other cultivated crops. The fact that the insects collect in large numbers on a few plants makes this control much easier. If the insects are found to be numerous on lamb's quarters or other weeds near beet fields, they may be killed with a hand torch or covered with straw and burned. A more satisfactory method would be to spray them with an insecticide that kills when it comes in contact with them. A spray of nicotine sulfate and soap, such as described below, would do this satisfactorily.

The more usual practice is to kill the insects when they are abundant in beet fields or gardens. A spray of nicotine sulfate should be applied at the rate of one pint to 100 gallons of water with 5 to 6 pounds of soap added. It is necessary to hit the insects in order to kill them, as this spray kills on coming in contact with the insect. When the spray strikes the foliage many of the insects will drop to the ground. They may be killed by spraying them before they crawl away. Nicotine sulfate is a tobacco product that contains 40 per cent of pure nicotine. Black-leaf 40 is a common brand, but there are others of the same strength on the market. Fish-oil soap is the cheapest and best soap to use, but a cheap laundry soap has good sticking qualities. The soap should be chipped up and then heated in about 2 to 3 gallons of water. When dissolved it is added to the water in the spray tank. The nicotine sulfate is then added, and the mixture is ready for use. Since the insects often collect on a few plants or in small portions of a field the spray may be more advantageously applied with a barrel pump or power sprayer than with a traction machine as advised for the webworm.

It is important that these insects be treated soon after they appear. A few hours' delay in applying control measures may mean the loss of much of the crop. If these insects are noted to be abundant on the weed hosts, growers should have a machine and the proper spray materials ready for application if the pests should start to migrate to their beet fields.

In some places large sticky shields made of tar paper covered with some sticky material are said to be effective in catching the full-grown insects. One man hits an infested plant with a stick and the insects fly from the plant on the side opposite to where it was struck. Here a second man stands with the sticky shield and any insects that fly against it are caught and held.

When the insects are migrating on foot a barrier of oil, tar, or tree tanglefoot will stop the pests.

7.—FLEA-BEETLES

Flea-beetles are small, black, green or striped insects that may be found feeding on the leaves of sugar-beets. The most common species³⁴ from mid-summer until fall has alternate dark and yellow stripes running lengthwise of the wings (Fig. 19). It is known as the banded flea-beetle. A small black species, probably the potato flea-beetle³⁵, is common in June when the beets are in the 2-leaf stage. Flea-beetles get their name from their ability to jump long distances with their powerful hind legs. If they are disturbed while they are feeding on a plant, they will give one hop and come down on another plant some distance beyond.



Fig. 19.—Banded flea-beetle (*Systema taeniata* Say). Enlarged 5 times.

Flea-beetles feed on the leaf tissue and make small holes in the foliage (Fig. 20). Instead of eating thru the epidermis on both sides of a leaf, this thin covering may be left on one side, and the injured area will appear as a white patch amid the green of the healthy leaf tissue. In any case the cells in and around the injured area are killed and the leaf is unable to function properly in manufacturing starchy food for the plant. If enough leaf tissue is destroyed the leaves turn brown, wither, and sometimes drop off.

Flea-beetles are often abundant early in the summer when sugar-beets are small and easily injured. The insects will often collect in large numbers on one plant, and this plant is often one that is already weakened and backward. Every small leaf may be killed in cases like this and, altho some plants are able to send out a new growth of leaves after the first leaves are killed, others are too weak to do this and die. Most flea-

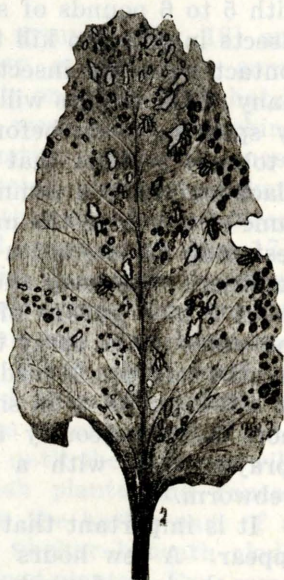


Fig. 20.—Banded flea-beetles and the result of their feeding on a leaf of a sugar-beet.

³⁴*Systema taeniata* Say

³⁵*Epitrix cucumeris* Harris

beetles are rather general feeders, but they often show a preference for certain food-plants over others. The banded flea-beetle, for example, is especially fond of lamb's quarters, rag-weed, poverty weed, and sugar-beets, but it feeds on many other plants, both weeds and cultivated crops. The presence of weeds in beet fields has much to do with the number of flea-beetles that are present.

Flea-beetles in their development pass thru four stages: egg, larva or grub, pupa, and adult or full-grown beetle. The eggs are deposited by the female beetle in the ground around some food-plant and the larvae or grubs that come from these eggs feed on the roots of these plants. This may either be some cultivated crop or a weed. The larva of the banded flea-beetle feeds mostly on the roots of lamb's quarters and some other weeds. The feeding of the larvae on the roots of most plants does not do much damage. From the standpoint of a beet grower it is only necessary to guard against the feeding of the full-grown beetles, and fortunately there is only one brood of these each year in most places.

Control.—Clean cultivation is an important practice in places where flea-beetles are abundant because weeds serve as the breeding place of many flea-beetles. The use of an abundance of irrigation water helps to keep down the number of flea-beetles. These insects do not like moist conditions. They are more destructive in dry years than in moist.

Flea-beetles are hard to destroy with a poison spray, but they may be kept from feeding on cultivated plants by the use of a repellant. Plants that are sprayed with Bordeaux-mixture are nearly free from the attack of flea-beetles. The insects do not like the taste of foliage treated in this way. The most efficient control method is to use a spray of poison Bordeaux-mixture. This is the regular Bordeaux-mixture with arsenate of lead at the rate of three pounds of the powder added to each 100 gallons of spray.

Bordeaux-mixture is made by dissolving 8 pounds of copper sulfate (blue vitriol) and 8 pounds of quicklime or stoneline in 100 gallons of water.

Arsenate of lead alone has a repellant effect on flea-beetles. In experimental work plants sprayed with arsenate of lead had but few more beetles present after spraying than those sprayed with poison Bordeaux-mixture.

Lime has some tendency to keep flea-beetles from plants. If powdered lime alone is dusted on plants it will keep away some of the insects, and if one pound of arsenate of lead is mixed with 8 pounds of lime the mixture will also have killing power for the

few insects that do feed on the treated foliage. This dust may be applied to the plants with a dust gun or in gardens the material may be dusted thru a bag made of cheese cloth.

8.—BLISTER-BEETLES

Blister-beetles are active, long-legged, insects that sometimes feed on the foliage of sugar-beets. This name is applied to several species of insects that vary greatly in color. Most of them are plain black, green, blue, or gray, but one common form or species that feeds on sugar-beets in Utah is gray with many small black spots on the wings. This one is known as the spotted blister-beetle³⁶. Another common form on sugar-beets is small and black (Fig. 21)³⁷. These insects vary in size from about one-half inch to an inch or more in length. In most species the head is much narrower than the breadth of the two wings.



Fig. 21.—A black blister-beetle (*Epicauta puncticollis* Mann.) Enlarged 2½ times.

Blister-beetles collect in large numbers and feed in one place. They will often be found feeding in one small spot in a large beet field. They may continue to feed here until these plants are completely destroyed or they may leave this feeding ground and fly to another some distance away. Here they may feed on the same crop or on a different one. In one case these beetles were known to migrate from a pea field to a rose garden early one morning. They fed on the rosebushes until the middle of this same afternoon when they again migrated. This time they moved to a peach orchard about a quarter of a mile away. So abundant were they that some rosebushes would harbor two or three hundred of the actively feeding insects. When at last they moved, there was not a leaf or a rose left on bushes that were in perfect condition six hours before.

Tho blister-beetles are usually general feeders, each kind will have certain plants that it prefers as food. The sugar-beet is a preferred food plant of the spotted blister-beetle as well as some other kinds. These insects will often feed on some of our common weeds near a beet field and migrate from these to the beets. Lamb's quarters, pigweed, sunflowers, sweetclover, and greasewood are common food plants. Peas, beans, potatoes, corn, and alfalfa are among the cultivated crops fed upon by many of

³⁶*Epicauta maculata* Say

³⁷*Epicauta puncticollis* Mann.

these insects. Sometimes the insects will feed on the foliage of peach and apple trees and entirely destroy it.

Blister-beetles get their name because they contain in their bodies a material known as cantharidin which is irritating to the skin of human beings. The commercial Spanish-fly is a product of the ground-up bodies of some of these beetles. In one case a blister-beetle was crushed on the arm of an entomologist who was watching a swarm feeding in a peach orchard. About 12 hours later the spot began to smart, and 24 hours later a water-blister over two inches in diameter had developed.

The blister-beetle in its development passes thru four stages: egg, larva or grub, pupa, and adult or full-grown beetle. The female beetle deposits her eggs in a little pocket dug in the ground. These eggs hatch into grubs that are small and active. They feed mostly on the eggs of grasshoppers. They search here and there to find a grasshopper egg-capsule, and at once eat into it. Since they feed on these eggs, they may in this stage be classed as insects that are beneficial to the farmer. The grub passes thru several stages in its development. These stages differ greatly in appearance from each other, and in each stage the grub is less active than in the one before. In the last stage the insect is entirely motionless, and it remains in this condition thru the winter. It will remain in this stage for even longer periods of time unless there is the right degree of moisture in the soil. They have been kept for two years when the soil was extremely dry. For this reason there is often some difference in the time that broods of blister-beetles may appear. There is only one brood a year with some of these insects, and apparently some take two or more years to complete their life cycles.

Because the grubs of blister-beetles feed on grasshopper eggs, these insects are often abundant in a year following a grasshopper outbreak. Tho the grubs are to some extent beneficial, the damage that the beetles sometimes do to cultivated crops more than offsets their beneficial habits. With more intensive cultivation of our valleys the blister-beetles have had to change from their old native plants to cultivated crops. For this reason it is often necessary to take active measures for their destruction.

Control.—When blister-beetles are infesting only a small portion of a field, they may often be driven out. Several men or boys should walk slowly thru the field beating the plants with sticks or brush. The beetles will crawl or fly ahead of the drivers and may be induced to collect on weeds or other plants, where their feeding is of little importance. Beetles may also be driven from fields into hay or straw and burned. Driving is

advisable when the beets are small and when equipment is not available for immediate spraying.

Spraying beets with Paris green, as for the sugar-beet web-worm, or with Bordeaux-mixture, as for flea-beetles, will keep blister-beetles away. Bordeaux-mixture acts as a repellant, while Paris green acts both as a poison and a repellant. Only a small percentage of the blister-beetles will feed on the plants treated with Paris green, and these will be killed. Most of them will seek unsprayed plants for their food.

Plants may also be dusted with Paris green and lime at the rate of one pound of Paris green to five of lime.

II.—INSECTS THAT FEED ON THE ROOTS OF SUGAR-BEETS

1.—SUGAR-BEET ROOT APHID

The sugar-beet root aphid³⁸ is a native of the western United States. It is not found east of Kansas and Nebraska, but it may be found in all of the Rocky Mountain and Pacific Coast states. It belongs to the group of insects commonly called plant lice and is sometimes called a root louse. Like all of these insects, the sugar-beet root aphid has piercing and sucking mouthparts that are driven into the tissues of its host. With these the sap is sucked from the leaves and roots of the plants on which it feeds. Most of the life of this small root aphid is spent on the roots of sugar-beets where it will be overlooked unless the plant is pulled up and examined.

Type of Injury.—The presence of a few aphids on the roots of a beet may not result in a change of appearance in the foliage of the plant. However, as the number increases the leaves become a lighter green than those of the uninfested plants. Still later these plants wilt and they may be killed if enough sap is removed by the feeding aphids.

The sugar-beet root aphid sucks the sap from the small rootlets as well as from the taproot. If the insects are abundant, many of the small rootlets will be killed, and the taproots may shrivel and become so flexible that they may be bent almost double without breaking.

Mr. Asa C. Maxson of the Great Western Sugar Company has conducted careful experiments to determine the amount of damage that may be done by this insect. This writer finds that the average sugar content is from $\frac{3}{4}$ to 1 per cent less in infested beets. The purity of the juice also averages 2.11 per cent less

³⁸*Pamphigus betae* Doane

in the infested beets. Maxson believes that a reduction of one ton per acre is a common result of the feeding of these insects and that in some cases the yield is reduced 2 or 2½ tons per acre. In very severe cases beets may suffer so much injury that they are not worth harvesting.

Host Plants.—The sugar-beet root aphid is a pest of sugar-beets, table beets, mangles and occasionally carrots and turnips. It may also be found during the summer on the roots of wheat, alfalfa, flax, salt-grass³⁹, bluejoint-grass⁴⁰, foxtail⁴¹, goldenrod⁴², knotweed⁴³, horseweed⁴⁴, dock⁴⁵, aster⁴⁶, and lamb's quarters. The insect is often found in immense numbers on lamb's quarters especially when it grows in a dry place.

In addition to the above summer hosts, this insect passes the winter in the egg stage on two common trees—the narrow-leaved cottonwood⁴⁷ and the balm of Gilead⁴⁸.

Description.—An aphid in its development goes thru a complicated life cycle. The principal forms are the egg, wingless viviparous females, winged viviparous females, and the sexual males and females.

Egg.—The egg is pale yellow and about 1/60 inch in length. These eggs are found under the bark of cottonwood trees.



Wingless Viviparous Females.—This form is oval, pale yellow-white with hind end of the body bearing a mass of white waxy filaments (Fig. 22). The forepart of the body appears dusted with a white powder. It is about 1/8 inch in length. These lice are found around the roots of sugar-beets and lamb's quarters.

Winged Viviparous Females.—This form of the insect has the front portion of the body black and the rear portion or abdomen green. There are two pairs of wings (Fig. 23). The entire insect appears to be lightly dusted with white powder. There is a small white flocculent mass on the rear end of the body. This form migrates from the sugar-beet to the cottonwood in the fall and from the cottonwood to the sugar-beet in early summer.

Sexual Males and Females—These small forms are wingless and yellow. They are to be found in the cracks of the bark of cottonwood trees for a few days in the fall.

Fig. 22—Wingless viviparous female of the sugar-beet root aphid (*Pemphigus betae* Doane). This form of the insect is found feeding on the roots of the sugar-beet. Enlarged 6 times.

Life History and Habits.—The sugar-beet root aphid has a complex life history. The winter is passed in two ways. It may be spent as a wingless form (Fig. 22) in the soil of a beet field that has been infested or it may be spent in the egg stage in crevices of the bark of cottonwood trees. There are two ways that a beet crop may

³⁹*Distichlis spicata*

⁴⁰*Agropyron occidentale*

⁴¹*Hordeum jubatum*

⁴²*Solidago canadensis*

⁴³*Iva xanthiifolia*

⁴⁴*Polygonum aviculare*

⁴⁵*Achillea millefolium*

⁴⁶*Rumex crispus*

⁴⁷*Populus angustifolia*

⁴⁸*Populus balsamifera*

become infested in the spring. Winged aphids may fly from the cottonwoods to the beets, or the insects that winter in the soil may feed on the roots of the new crop.

In tracing the changes that a root aphid undergoes in its development, let us start with the insect on the roots of a sugar-

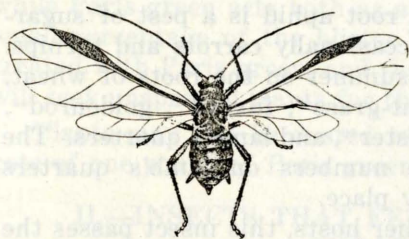


Fig. 23—Winged migrant of the sugar-beet root aphid (*Pemphigus betae* Doane). This form of the insect flies from cottonwoods to sugar-beets. Enlarged 5 times.

beet. These small forms suck the sap from the rootlets as well as from the taproot during the summer. Their presence is indicated by a white moldy mass in the soil around the beet. In the fall, some of these wingless aphids remain in the soil of the beet field; others will develop wings (Fig. 23) and fly to the narrow-leaved cottonwood. This migration may cover a month,

and sometimes there will be thousands of these small, winged insects in the air.

Aphids do not reproduce by eggs thruout the year. Tho there are often eight or ten generations a year, only the female of the last generation in the fall deposits eggs. Thruout the summer the mature females give birth to small living aphids. They do this, moreover, without any males being produced. Each brood is made up entirely of females, and each female of this brood gives birth to a new brood that is all females. Females of this kind that do not reproduce by eggs but rather produce living young are spoken of as viviparous females. Females that are able to give birth to young without the presence of male aphids are said to develop by parthenogenesis. During the summer, then, the sugar-beet root aphid increases its numbers by several generations of the insect on the roots of sugar-beets in the manner described above. Most of these aphids on the sugar-beet are wingless, but in the fall some with wings are produced and these fly to the narrow-leaved cottonwood or balm of Gilead. On the cottonwood these winged insects crawl down the trunk of the tree, and finally, in some protected place under the bark near the base of the tree, they give birth to a few very small yellow, wingless aphids. These wingless forms are the true sexual aphids. Some will be males but most will be females. In appearance they are very similar. After these sexual forms have mated each female deposits one yellow egg in a crevice in the bark of a tree. This egg remains here, protected from the cold during the winter.

When the weather warms up in the spring and the leaves of the cottonwood open out each small egg gives birth to a wingless aphid known as the stem-mother. This aphid crawls to the upper side of a cottonwood leaf and begins to feed by sucking the sap from the leaf. The tissue of the leaf is irritated by the



Fig. 24—A gall made by a sugar-beet root aphid on the leaf of a cottonwood. The young lice live and grow in this gall.

saliva injected during the feeding of the aphid with the result that the leaf bulges downward at the point of feeding until a pocket containing the aphid is formed in the leaf near the midrib. This pocket or gall (Fig. 24) is light green in color and is closed except for a small opening in the upper side of the leaf. In this pocket the aphid develops and gives birth to from 75 to 175 young. These develop within the gall amid a mass of white waxy threads. When these aphids become full-grown, they have wings. The gall breaks open during late June and July, and the small aphids fly or are blown in all directions. In this flight many reach sugar-beets or lamb's quarters where they settle on the leaves and feed for a few days before they give birth to wingless forms that crawl down to the roots of the sugar-beet and start the infestation that may cause so much damage.

The aphids on the roots of beets then may come from the winged forms that fly from the cottonwoods or they may be already in the soil as wingless forms that hold over from the year before. The percentage of the aphids present on sugar-beets that may develop wings and fly to the cottonwoods depends in part on the condition of the soil during mid-summer. If the soil is dry, more winged aphids will be produced than when the soil is well irrigated. The sugar-beet root aphid does not thrive under moist soil conditions. If the spring and early summer is dry (as it was in Utah in 1924) they will be more abundant than when the early part of the summer is rainy and wet.

Root aphids sometimes go from one beet to another when they are working on the roots during the summer. This is especially true immediately after irrigation. The aphids do not like the moist condition of the soil and they come to the surface, crawl around, and often go down on the roots of another beet in search of more favorable living conditions. In this way the infestation late in the summer often affects more beets than was the case at the time of the early migration from the cottonwoods.

Enemies of the Sugar-beet Root Aphid.—The sugar-beet root aphid has many enemies that tend to keep down its numbers. Certain lady-beetles feed on them and destroy many. Small, flat maggots, which are the larvae of black and yellow syrphus flies, have a great liking for the aphids. A fungous disease will also kill some of them.

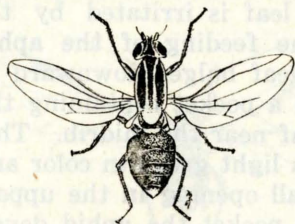


Fig. 25.—A fly, the maggot of which feeds on the sugar-beet root aphid. Enlarged 8 times.

The most important insect that lives on the root aphid, however, is a small fly (Fig. 25) with yellow marks running lengthwise on its back. This small fly⁴⁹ places its eggs in the ground around beets or lamb's quarters. It seems to know instinctively which plants are infested, as its larvae or maggots are found only where there is an infestation of aphids. The maggots that hatch from these eggs approach an aphid, make a hole in its skin and suck the blood from its body. One maggot will in this manner destroy many of the pests during its lifetime.

During the summer these small flies are numerous all thru the beet fields. They may be seen resting on the beet foliage and are often present in large numbers on foliage in nearby orchards and on grass in meadow land.

Control.—The control of the sugar-beet root aphid has been thoroly studied in Montana⁵⁰, and the following control suggestions are based on this work.

The root aphids that winter as wingless forms in the soil from year to year have but little influence on the succeeding crop. These aphids feed on the roots of many weeds and grasses, and a survey of beet fields as well as counts of the number of aphids present in several types of fields has shown that the number present the year after a field is in beets is but little if any greater than the number present the year after a field is in grain, alfalfa, or several other cultivated crops. In other words, the number present when beets follow beets is about the same as when beets follow alfalfa, grain, or any other crop. Rotation, therefore, is not effective in controlling the sugar-beet root aphid.

It is the winged root aphids from the cottonwoods that are indirectly responsible for most of the damage to sugar-beets. These aphids migrate to beet fields during the latter half of

⁴⁹*Chloropisca glabra* Meig.

⁵⁰This work was done by J. R. Parker and Asa C. Maxson

June and the first half of July. They alight on the leaves of sugar-beets and here give off young that go down to feed on the roots. The continued feeding of these root forms causes the damage to the crop. It is known that these aphids do not thrive under moist conditions, and experimental work has shown that when the soil around beets is kept moist during the time of migration of the winged aphids from the cottonwoods that little injury is experienced. The young may be produced, but they do not go down and multiply on the roots. Early irrigation is advised. For this reason beets should be watered in June as well as in July. Experimental work has shown that early irrigation will also increase the tonnage and sugar content and aid in the reduction of certain fungous diseases found on beets. The number of irrigations as well as the time of application has a great influence on the number of aphids present. A survey showed that beet fields irrigated five times had only half as many infested plants as those that were irrigated twice. The amount of moisture in the top soil has an influence on the abundance of lice. By growing beets in flower pots it was found that if the beet was watered from below and if two inches of dry dirt were present on the top of the pot that the root aphids were very abundant. If the same amount of water was applied to the top of the pot and the top soil was moist there were almost no root aphids present. Fields that are sub-irrigated have more of these insects than those that are top-irrigated. This is because the top crust is drier in the former type of field. If this crust is allowed to get so dry that it cracks, it makes a means of easy entrance for the aphids to the roots of the beet.

Since the cottonwood acts as a breeding ground for this aphid the destruction of this tree would remove a constant source of infestation in beet-fields. The balm of Gilead, or native cottonwood, and the narrow-leaved cottonwood both act as hosts for these aphids. In the migration from the cottonwood the wind sometimes plays an important part. The winged aphids are helped in their flight by even a moderate breeze, and beet fields that are in a position so that the prevailing winds will carry the aphids from the cottonwoods will receive more than those that are not so located. In some cases the aphids may even be brought to beet fields from cottonwoods in the mountains by the canyon breezes.

The control of root aphids may be brought about, then, by destroying the cottonwoods and by practising early and frequent irrigation. It is especially important that water be applied in June and July when winged migrants come to sugar-beets from the cottonwoods.

2.—SUGAR-BEET ROOT-MAGGOT

The sugar-beet root-maggot⁵¹ is not a pest of general distribution. Its ravages in Utah have so far been mostly restricted to Cache Valley, tho its presence has been reported locally in Emery and Box Elder Counties. It is apparently a native insect that has fed for many years on native weeds such as lamb's quarters, red-root and prostrate pigweed. Now it seems to be adding the sugar-beet to its list of preferred food-plants.



Fig. 26—A sugar-beet that shows the feeding marks of the sugar-beet root-maggot.

Nature of Injury.—All of the injury from this insect is caused during the maggot or larva stage. These forms feed on the taproot and root-lets beneath the ground. Wherever a maggot feeds on a beet root, the tissues are broken and a black area is produced. From the wound the sap flows and the soil around a plant may be soaked. If the maggot in its feeding cuts off the tip of the taproot the plant will wilt and die. This will occur when the field is so dry that the maggot has gone deep in the ground to find favorable moisture conditions.

Description—The sugar-beet root-maggot passes thru four stages in its development: egg, larva or maggot, pupa, and adult or fly.

Egg.—The egg is white, slender, slightly curved, and $1/25$ of an inch in length.

Larva or Maggot.—The maggot (Fig. 28) is white, without legs, eyes or distinct head. It is largest at the rear end and tapers like a cone with the head as its apex. It is about $1/4$ inch in length.

Pupa.—This stage is passed within a brown covering, the puparium. It is oval, brown, and slightly shorter than the maggot.

Adult or Fly.—The fly is about $1/4$ inch in length, black with transparent white wings except for a black area on the front margin about $1/3$ of the distance from the base to the apex of the wing (Fig. 27).

Life History and Habits.—The sugar-beet root-maggot passes the winter as a maggot (Fig. 28) in the soil of old beet fields. In the fall it goes down from a few inches to a foot in the soil. During May of the next year it comes up near the surface of the ground and changes first to the brown pupa and then to a fly. About thinning time this fly (Fig. 27) deposits its eggs

⁵¹*Tetanops aldrichi* Hendel

in the ground around sugar-beets, lamb's quarters, and other weed hosts. The maggots that hatch from these eggs crawl down and begin at once to feed on the root of the beet (Fig. 26). Most of the maggots continue to feed for the remainder of the summer and then work their way down deeper in the ground where they pass the winter. There is only one main brood, tho a small second brood occurs in some years.

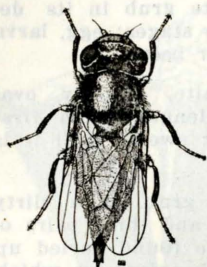


Fig. 27—The female fly that is the adult form of the sugar-beet root-maggot (*Tetanops aldrichi* Hendel). Enlarged 4 times.

This insect thrives in dry, sandy soil, tho it has been found sparingly in heavier soils. The greatest injury has occurred during July and August where fields have been allowed to become dry and the maggots have gone deep in the ground to find the proper degree of moisture. Under these conditions they feed down toward the tip of the taproot and often cut it off. Ten to thirty maggots have often been found around one beet and in one case sixty-four were found around one plant.

In the spring of 1922 thousands of eggs were deposited in the beet fields. In some fields the average was at least twenty to a beet. In spite of this there was no injury from this insect during that year. The reason for this is believed to be that the soil in the beet field was so dry and hot that many eggs shriveled before hatching time. The soil temperature and soil moisture conditions at the time eggs are deposited have considerable influence on the number of root-maggots that will be present.

Control.—Tho no definite control for this insect is known, it is believed that watering the beets freely during late June and July will keep the maggots feeding so high on the roots that no serious damage will result from their feeding.



Fig. 28—The sugar-beet root-maggot (*Tetanops aldrichi* Hendel). It feeds on the roots of the sugar-beet. Enlarged 3 times.

3.—WHITE GRUB

White grubs are the larva or grub stage of the large brown beetles known as June bugs or May beetles⁵².

Type of Injury.—Sometimes these large C-shaped grubs feed on sugar-beets and eat thru the taproot. As a result of this feeding the leaves of the beet wilt and the plant dies. At

⁵²*Lachnosterna* sp.

other times the grubs will eat large holes in the side of the taproot. This area turns black and beets of this kind wilt during the hot part of the day. This is especially true if the grub has also eaten off many of the rootlets.



Fig. 29—A white grub.
About natural size.

Description.—The white grub in its development passes thru four stages: egg, larva or grub, pupa, and adult or beetle.

Egg.—The egg is white, slightly oval and about $1/10$ inch in length when first laid. After a few days it swells until it is nearly round.

Larva or Grub.—The grub is a dirty white with a brown head and three pairs of legs (Fig. 29). It will be found curled up like the letter "C" near the plant on which it has been feeding. When full-grown the grub is 2 inches or more in length.

Pupa.—The pupa is white, soft-bodied, and found in an earthen cell.

Adult Beetle.—The beetle is large, brown, broad, and heavy-bodied (Fig. 30).

Life History and Habits.—The May beetle (Fig. 30), the parent insect of the white grub, migrates to shade trees and feeds on the foliage during the night. Cottonwood, willow, and maple are preferred. After a night's feeding the beetles fly in a body to meadows and small grain fields where they feed during the day. In these migrations the insects are attracted to light. Some fly thru open windows; others collect in hundreds around street lights.

The eggs of the May beetle are deposited in the soil at a depth of one to six inches. They are sticky and surrounded by a coating of dirt. Each female may deposit from 50 to 100 eggs. The eggs hatch in about two or three weeks into small white grubs (Fig. 29) which at once begin to feed on the roots of grass or other plants. Because of their small size, they do but little damage the first year. As cold weather approaches the grubs go deep in the soil and remain until spring. Then they again come up near the surface and feed on the roots of the crop (Fig. 31) that was planted in the infested field. If this is a crop that is susceptible to their attack, considerable damage may result, as this is the year of their heaviest feeding. In the fall of their second year, they again go deep into the ground to pass the winter. In the spring of their third year, they move up in the ground, feed for



Fig. 30—A May beetle or June bug. This is the adult form of a white grub. About natural size.

a few weeks on the roots of plants, and then turn to the pupa stage within an earthen cell. In the fall of this year the pupa changes to a beetle, but the beetle does not come out until the following spring. Most May beetles, then, take three years to complete their cycle of life. The greater part of this time is spent in the white grub or larva stage, but only in the second year of its life as a grub does it do much damage by its feeding. Skunks feed on white grubs as do many birds, especially crows and crow blackbirds.

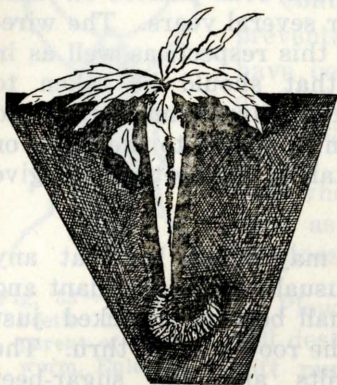


Fig. 31.—A white grub feeding on the taproot of a sugar-beet.

Control.—The control of white grubs is largely a question of crop rotation. Since this grub does most of its feeding during its second year, crops that may be damaged by grubs should not be planted in fields that were in sod or small grain the year before. Fields of this kind are chosen by the beetles as a place to deposit their eggs. Sugar-beets, potatoes, corn, and strawberries are most open to attack; while alfalfa, clover, buckwheat, and peas suffer but little injury. The female beetles will seldom place their eggs in ground that is planted to row crops if these crops are well cared for. However, if grass or weeds are allowed to grow in beet fields, the beetles will sometimes deposit eggs there. This may explain the fact that grubs have been found working in fields in Utah that have been in sugar-beets each year for six or more years. The main precaution, then, is to avoid planting sugar-beets on newly-turned sod land. The year following one in which there was a flight of May beetles is the year when there will be white grub injury.

Plowing in July or August will destroy many of the soft-bodied pupae. If plowing is done after this time and the pupae have turned to beetles they are more difficult to kill.

Hogs turned into infested fields will root up and feed on many white grubs. One hundred pigs and eight sows destroyed 99 per cent of the grubs in the soil of a 10-acre cornfield in Illinois in 27 days. It was estimated that each pig ate 11,278 grubs. This amount would weigh about 25 pounds.

4—WIREWORMS

Wireworms⁵³ are brown, hard-shelled grubs that may be injurious to the roots of sugar-beets in Utah. Where they are injurious it is usually because beets have been planted on land that has been a meadow or pasture for several years. The wireworm is much like the white grub in this respect, as well as in its life history and the precautions that should be taken to prevent injury from it. The injury from wireworms is reported from time to time, very little is known in regard to the kinds or species of wireworms that occur in Utah or the beetles that give birth to them.

Type of Injury.—The wireworms may attack beets at any stage of their development, they are usually more abundant and injurious about thinning time. A small beet is attacked just below the surface of the ground and the root is eaten thru. The



Fig. 32—A wireworm. This is the immature stage of a click beetle. Enlarged 2 times.

top wilts and the sugar-beet usually dies, in spite of the effort of the plant to obtain moisture by producing an extra growth of rootlets. When sugar-beet roots are attacked by wireworms a black spot marks the point of attack. If a beet is half-grown or more when the pest finds it, the wireworm may just eat a hole in the side of the beet. The plant is not usually killed, but it may bleed and lose considerable sap.

Description.—Wireworms in their development go thru four stages: egg, larva or wireworm, pupa, and adult or click beetle. Only the wireworm and click beetle are to be described.

Wireworm.—Wireworms are hard-shelled, oval or round in cross-section, elongate, glossy and colored in various shades of tan or brown. They vary in size, depending on their age, but may be an inch or more in length. Some wireworms have two horns or projections on the rear end of the body (Fig. 32).

Beetle.—The parent beetle of the wireworm is dark brown, long and narrow. When the beetle is placed on its back, it gives a snap that throws it over on its feet. Because of the sound produced in this act it is called a click beetle (Fig. 33).

Life History and Habits.—A wireworm (Fig. 32) lives as a larva in the ground from two to four years. During this time it feeds on the roots of grass or some cultivated crop. When the wireworm is full-grown, it changes during midsummer to a pupa within an oval cell near its feeding ground. The click beetle (Fig. 33) that comes from this pupa does not usually appear until May or June of the following year. After mating in

⁵³The larvae of beetles of the family Elateridae.

the spring, eggs are deposited by the female beetle in the soil of meadows and pastures, and the young wireworms from these eggs at once begin feeding.



Fig. 33—A click beetle. This is the parent of a wireworm. Enlarged 2 times.

Control.—A short rotation is the best preventative for wireworms. Meadows that have been in sod for three or more years often harbor many of these pests. Sugar-beets should not be planted the year following the plowing-under of sod. Peas, buckwheat, and small grains are not damaged as much as are sugar-beets, corn, and potatoes.

Plowing in late summer and early fall will destroy many wireworms that are in the soft pupa stage. Other control methods that may work satisfactorily in a small garden or truck farm are not practical for a field of sugar-beets and will not be discussed here.